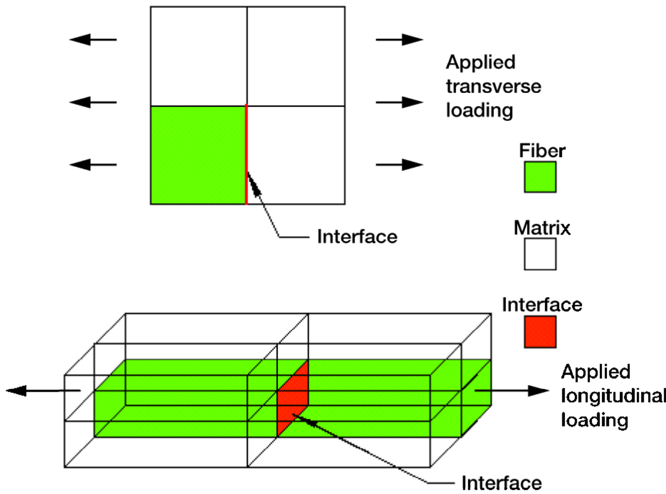
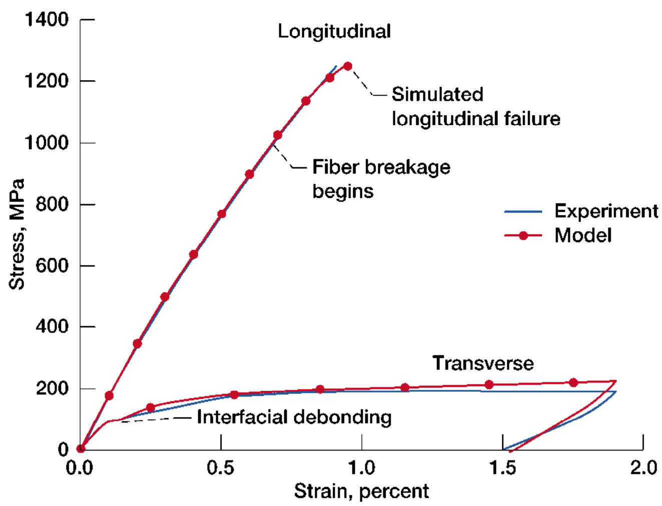
# Local Debonding and Fiber Breakage in Composite Materials Modeled Accurately

A prerequisite for full utilization of composite materials in aerospace components is accurate design and life prediction tools that enable the assessment of component performance and reliability. Such tools assist both structural analysts, who design and optimize structures composed of composite materials, and materials scientists who design and optimize the composite materials themselves. NASA Glenn Research Center's Micromechanics Analysis Code with Generalized Method of Cells (MAC/GMC) software package (http://www.grc.nasa.gov/WWW/LPB/mac) addresses this need for composite design and life prediction tools by providing a widely applicable and accurate approach to modeling composite materials. Furthermore, MAC/GMC serves as a platform for incorporating new local models and capabilities that are under development at NASA, thus enabling these new capabilities to progress rapidly to a stage in which they can be employed by the code's end users.

A recent effort (done in conjunction with the Ohio Aerospace Institute (NCC3-650)) that has leveraged many of the existing capabilities of MAC/GMC is the development and implementation of a new interfacial model (ECI) to simulate internal debonding (or local failure) within composite materials. This model is unique in that it allows stress reduction to occur in the region of the composite local to the failure event as interfacial separation continues. In addition, the ECI model can be applied to simulate both transverse fiber-matrix interfacial debonding and longitudinal fiber breakage in continuously reinforced composite plies. For interfacial debonding, a simulated weak interface is placed at the fiber-matrix interface, whereas for longitudinal fiber breakage, a simulated weak interface (which will represent a fiber break) is placed within the fiber itself (see the following figure). To allow more accurate simulation of composites and to incorporate the statistical nature of fiber strength, researchers must employ more complex (and realistic) geometric representations (refs. 1 and 2). Sample results of MAC/GMC with the ECI model are shown in the final figure. In the longitudinal simulation, the model agrees well with the experiment not only for the composite deformation, but also for the global failure of the composite. The transverse simulation does an excellent job capturing the details of the knee associated with debonding. The ECI model also functions in concert with the other features in MAC/GMC such as arbitrary time-dependent multiaxial loading histories, laminate analysis, yield/damage surface generation, and an interface with the ABAQUS finite element package.




*Application of the ECI debonding model to transverse interfacial debonding and longitudinal fiber breakage.*




*Simulated and experimental longitudinal and transverse tensile response of SCS-6/TIMETAL21S at 650 °C.*

# References


1. Bednarcyk, Brett A.; and Arnold, Steven M.: A New Local Failure Model With Application to the Longitudinal Tensile Behavior of Continuously Reinforced Titanium Composites. NASA/TM--2000-210027, 2000. http://gltrs.grc.nasa.gov

2. Bednarcyk, Brett A.; and Arnold, Steven M.: A New Local Debonding Model With Application to the Transverse Tensile and Creep Behavior of Continuously Reinforced Titanium Composites. NASA/TM--2000-210029, 2000. http://gltrs.grc.nasa.gov



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